

WHAT IS CLAIMED IS:

1           1.       An apparatus to make a certain volume of liquid available for  
2 atomization, the apparatus comprising:  
3           a container adapted to hold a liquid; and  
4           a piston pump comprising a piston member and a valve body, wherein the  
5 piston member is slidable within the valve body, and wherein the valve body functions with  
6 the piston member to define a metering chamber, wherein the metering chamber is adapted to  
7 be filled with liquid from the container when the piston member is moved to a filling  
8 position, and wherein the piston pump is adapted to dispense a known volume of the liquid  
9 from the metering chamber when the piston member is moved to a dispensing position.

1           2.       An apparatus as in claim 1, further comprising a biasing member  
2 disposed between the container and the piston member to bias the piston member in the  
3 direction of the dispensing position and to require a force to be placed on the piston member  
4 to move the piston member to the filling position.

1           3.       An apparatus as in claim 2, wherein the piston member has a proximal  
2 end and a distal end, wherein the piston pump further comprises a tubular valve seat slidably  
3 disposed about the distal end of the piston member such that the liquid within the metering  
4 chamber moves the tubular valve seat distally over the piston member to allow the liquid in  
5 the metering chamber to be dispensed by flowing between the piston member and the tubular  
6 valve seat when the piston member is moved toward the dispensing position.

1           4.       An apparatus as in claim 3, wherein the tubular valve seat is slidable  
2 within the valve body, wherein the valve body defines a stop to stop distal movement of the  
3 tubular valve seat relative to the piston member, and wherein the biasing member forces the  
4 distal end of the piston member into a distal end of the tubular valve seat to provide a seal  
5 between the piston member and the tubular valve seat.

1           5.       An apparatus as in claim 4, wherein the proximal end of the piston  
2 member includes a resilient frontal end that contacts the valve body.

1           6.       An apparatus as in claim 5, wherein a proximal portion of the valve  
2 body includes a set of crenellations that provide fluid passageways to the liquid in the  
3 container, and wherein the resilient frontal end is moved over the crenellations when in the

4 filling position, and wherein a vacuum is created within the metering chamber while the  
5 piston member is being moved to the filling position such that liquid within the container is  
6 drawn into the metering chamber when the piston member is at the filling position.

1 7. An apparatus as in claim 6, wherein the valve body includes an  
2 expansion region distal to the crenellations, wherein the distance between the expansion  
3 region and the crenellations defines a valve stroke where the vacuum is created in the  
4 metering chamber during movement to the filling position, and wherein the volume of the  
5 liquid dispensed is determined based on the stroke.

1 8. An apparatus as in claim 4, wherein the distal end of the piston  
2 member has a rounded surface, and wherein the distal end of the tubular valve seat includes a  
3 conical portion to mate with the distal end of the piston member and to provide a line seal  
4 when received into (the rounded portion.)

1 9. An apparatus as in claim 8, wherein the tubular valve seat further  
2 includes a buffer channel that extends distally from the rounded portion to prevent  
3 contaminated liquid from passing back up into the container.

1 10. An apparatus as in claim 1, further comprising a tube piston slidably  
2 disposed within the container, wherein the tube piston slides toward the piston pump as liquid  
3 is drawn out of the container and into the metering chamber.

1 11. An apparatus as in claim 1, wherein the metering chamber defines a  
2 volume in the range from about 10 microliters to about 150 microliters.

1 12. An apparatus for nebulizing a liquid, the apparatus comprising:  
2 a housing;  
3 a vibratable member disposed within the housing, the vibratable member  
4 comprising a front surface, a rear surface, and a plurality of apertures extending  
5 therebetween;

6 a liquid supplier disposed within the housing which is adapted to deliver a  
7 certain volume of liquid to the rear surface; and

8 a vibrator which vibrates the vibratable member to eject liquid droplets from  
9 the front surface of the vibratable member;

10 wherein the liquid supplier comprises a container adapted to hold a liquid, and

11 a piston pump comprising a piston member and a valve body which function together to  
12 define a metering chamber, wherein the metering chamber is adapted to be filled with liquid  
13 from the container when the piston member is moved within the valve body to a filling  
14 position, and wherein the piston pump is adapted to dispense a known volume of the liquid  
15 from the metering chamber when the piston member is moved to a dispensing position.

1 13. An apparatus as in claim 12, wherein the piston member has a distal  
2 end which is disposed in the vicinity of the rear surface of the vibratable member.

1 14. An apparatus as in claim 12, wherein the apertures are tapered to  
2 narrow from the rear surface to the front surface.

1 15. An apparatus as in claim 12, further comprising a tube piston slidably  
2 disposed within the container, wherein the tube piston slides toward the piston pump as liquid  
3 is drawn out of the container and into the metering chamber.

1 16. An apparatus as in claim 12, wherein the piston member has a  
2 proximal end and a distal end, wherein the piston pump further comprises a tubular valve seat  
3 slidably disposed about the distal end of the piston member such that the liquid within the  
4 metering chamber moves the tubular valve seat distally over the piston member to allow the  
5 liquid in the metering chamber to be dispensed by flowing between the piston member and  
6 the tubular valve seat when the piston member is moved toward the dispensing position,  
7 wherein the distal end of the piston member has a rounded surface, and wherein the distal end  
8 of the tubular valve seat includes a conical portion to contact the distal end of the piston  
9 member and to provide a line seal when received into (the rounded portion.)

1 17. A method to make a certain volume of liquid available for atomization,  
2 the method comprising:

3 drawing liquid from a container into a metering chamber with a vacuum to fill  
4 the metering chamber with liquid; and

5 dispensing a known volume of the liquid from the metering chamber such that  
6 a known volume of the liquid is available for atomization.

1 18. A method as in claim 17, further comprising providing a piston pump  
2 to draw the liquid from the container, wherein the piston pump includes a piston member that

3 is slidable within a valve body, and wherein the piston member and the valve body function  
4 to define the metering chamber.

1 19. A method as in claim 18, further comprising moving the piston  
2 member to a filling position to fill the metering chamber with liquid, and moving the piston  
3 member to a dispensing position to dispense the liquid from the metering chamber.

1 20. A method as in claim 19, further comprising biasing the piston member  
2 in the direction of the dispensing position to require a force to be placed on the piston  
3 member to move the piston member to the filling position.

1 21. A method as in claim 20, wherein the valve body operably connected  
2 to the container and includes crenellations that provide fluid passageways to the container,  
3 wherein the piston member is slidable within the valve body, and further comprising sliding  
4 the piston member to the filling position where liquid flows through the crenellations to fill  
5 the metering chamber.

1 22. A method as in claim 21, wherein the piston member has a proximal  
2 end and a distal end, wherein the piston pump further comprises a tubular valve seat slidably  
3 disposed about the distal end of the piston member such that when the piston member is  
4 biased in the direction of the dispensing position, the liquid within the metering chamber  
5 moves the tubular valve seat distally over the piston member to allow the liquid in the  
6 metering chamber to be dispensed by flowing between the piston member and the tubular  
7 valve seat.

1 23. A method in claim 22, wherein the tubular valve seat is slidable within  
2 the valve body, and further comprising stopping distal movement of the tubular valve seat  
3 relative to the piston member with a stop on the valve body after the known volume of the  
4 liquid has been dispensed from the metering chamber.

1 24. A method as in claim 22, wherein the distal end of the piston member  
2 has a rounded surface, and wherein biasing of the piston member forces the distal end of the  
3 piston member into a conical portion within the tubular valve seat to provide a line seal  
4 between the piston member and the tubular valve seat.

1                   25.     A method as in claim 24, wherein the valve seat includes a buffer  
2 channel distal to the conical portion, and further comprising permitting undispensed liquid to  
3 collect in the buffer channel.

1                   26.     A method as in claim 21, wherein the proximal end of the piston  
2 member includes a resilient frontal end to contact the proximal end of the piston member  
3 against the valve body, and further comprising proximally moving the resilient front end to  
4 create the vacuum within the metering chamber so that when the piston member reaches the  
5 filling position, liquid within the container is drawn into the metering chamber.

1                   27.     A method as in claim 26, wherein the valve body further includes an  
2 expansion region distal to the crenellations, and further comprising moving the resilient  
3 frontal end a full stroke from the crenellations to the expansion region to dispense the known  
4 volume.

1                   28.     A method as in claim 27, further comprising varying the distance  
2 between the expansion region and the crenellations to change the volume dispensed.

1                   29.     A method as in claim 17, wherein the container includes a tube piston  
2 that is slidably disposed within the container, and further comprising permitting the tube  
3 piston to slide toward the tubular valve seat as liquid is drawn out of the container and into  
4 the metering chamber.

1                   30.     A method as in claim 17, wherein the known volume of dispensed  
2 liquid is in the range from about 10 microliters to about 150 microliters.

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